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(54) Title of the Invention: Method and Device for Manufacturing Semiconductor Devices

(57) Abstract

[Problem]: To provide a semiconductor manufacturing device that has a mechanism that controls polishing in response to the results of measurements by automatically measuring the reflectivity or film thickness of the film being polished while it is being polished. To provide a method of manufacturing semiconductor devices that can stop the polishing process based on the reflectivity or the desired film thickness by measuring the reflectivity or the film thickness of the film being polished while it is being polished.

[Means of Solving the Problem]: To use optical means to measure the reflectivity of a film surface that is being polished or the film thickness of a film that is being polished from the rear side of the polishing cloth through an optical window made in said polishing cloth at the same time that the polishing is taking place, using methods of manufacturing semiconductor devices that polish wafers with films that are being polished using polishing cloths.

[See source for diagrams.]

Scope of Patent Claims

[Claim 1]A method of manufacturing semiconductor with the following characteristics. In methods of manufacturing semiconductor devices that polish wafers with film that is to be polished using a polishing cloth, the aforementioned polishing cloth contains at least one optical window and through that window while polishing is underway, the reflectivity of the film surface being polished or the film thickness of the film being polished is measured from the back side of the aforementioned polishing cloth using optical means.

[Claim 2]The method of manufacturing semiconductor devices described in Claim 1 with the following characteristics. The film thickness or the reflectivity of the surface of the polished film measured using the optical means described above is used to stop the polishing when a specific value has been reached.

[Claim 3]The method of manufacturing semiconductor devices described in Claim 1 with the following characteristics. Using an optical means of measuring, the degree of polishing is altered in response to the thickness of the polished film or the reflectivity of the surface of the polished film.

[Claim 4]A semiconductor manufacturing device equipped with the following features and measuring device. A wafer with a film to be polished is to be polished in a semiconductor manufacturing device that polishes using a polishing cloth. In this sort of device, the polishing cloth has at least one opening. Behind that opening, from behind the polishing cloth while polishing is underway, an optical means is used to measure the reflectivity of the film surface being polished or the film thickness of the film being polished on the wafer's surface.

[Claim 5]The semiconductor manufacturing device described in Claim 4 with the following characteristics. The opening in the polishing cloth is configured using materials with a high transmitivity with respect to the light used in the measurements.

[Claim 6]The semiconductor manufacturing device described in Claim 4 with the following characteristics. A control device that changes the concentration of the polishing agent in the slurry in response to the reflectivity of the film surface being polished or the film thickness of the film being polished.

[Claim 7]The semiconductor manufacturing device described in Claim 4 with the following characteristics. A control device that changes the rpm of the wafer or the rpm of the base disk to which the polishing cloth is affixed in response to the reflectivity of the film surface being polished or the film thickness of the film being polished.

[Claim 8]The semiconductor manufacturing device described in Claim 4 with the following characteristics. A control device that changes the pressure applied to the wafer with respect to the polishing cloth in response to the reflectivity of the film surface being polished or the film thickness of the film being polished.

[Detailed Explanation of the Invention]

[0001]

[Technical Fields of the Invention]

The present invention relates to a device and method for flattening the surface of a semiconductor device, and in particular, it relates to the flattening of semiconductor device surfaces using CMP (Chemical Mechanical Polishing).

[0002]

[Prior Art]

With the microminiaturization and higher degrees of integration in semiconductor devices, surface irregularities in semiconductor devices have become a problem. For this reason, the CMP method has been getting attention as a method for flattening surfaces. The following is a simple description of conventional CMP methods. First, when the polishing cloth in the CMP device is replaced and polishing is begun, a sample-use wafer is polished in order to measure the reflectivity. Note that the initial film thickness of the sample wafer is measured in advance. After polishing, the remaining film thickness, the initial film thickness and the polishing time are used to calculate the polishing rate. Subsequently, when polishing the wafer, this polishing ratio is used to calculate the amount of polishing time needed to reach the desired film thickness.

[0003] However, the polishing ratio in CMP methods varies with the surface state of the polishing cloth. For this reason, when polishing large numbers of wafers for long periods of time, there will be changes in the polishing ratio, which causes the problem of variations in the amount of residual film thickness. With conventional CMP methods, it has been necessary to review the polishing time settings every several wafers in order to keep this sort of variation to a minimum. This review process requires large amounts of time and effort and has been a cause of lower throughput.

[0004] A method for solving this sort of problem has been proposed, in which the film thickness measurements are made at the same time that the polishing is carried out (JSP H-05-309559). This method is explained briefly in Figure 5. Figure 5 (a) shows a conventional example of a cross-section of a polishing device. Figure 5 (b) is a flat diagram excluding the upper lathe. The wafers 113 are held in the carrier 112, which moves in a sort of planetary motion, while the wafer is polished with pressure from the base disk 111 and the upper lathe 110. These wafers 113 extend partially beyond the lathes 110 and 111 which are above and below during the polishing process. At the measuring point 114, the laser displacement sensors 115 and 116, which are installed above and below, are used to detect the position of the upper and lower wafer surfaces and the film thickness is measured using a computation process.

[0005] With this method, however, the peripheral portions of the wafer that extend beyond the edge are only polished for short periods of time compared with the other, inner portions that do not extend over the edge. Thus, the problem arises that the actual film thicknesses in the measured areas and the other areas differ. Furthermore, in this polishing device, the film thicknesses are computed after measuring positions on the upper and lower surfaces of the wafer. However, if interference methods are used, the precision of the film thickness measurements will be inferior to those afforded by direct methods of measuring polished film. Additionally, two laser displacement sensors are required to measure the positions from above and below the wafers, which reduces the economic efficiency.

[0006]
[Problems the Invention is to Solve]

As above, with polishing methods that employ conventional CMP devices, differences emerge between the polishing times of the areas that are polished and the areas where film thicknesses are measured. This makes it impossible to obtain accurate film thickness measurements and makes it difficult to stop polishing when the desired film thickness has been reached.

[0007] The main purpose of the present invention is to provide a method for manufacturing semiconductor devices that can stop polishing based on the desired film thickness or reflectivity using the direct measurement of the reflectivity or film thickness of the films being polished as they are being polished and in the areas being polished.

[0008] The second purpose of the present invention is to provide a semiconductor manufacturing device that has a mechanism to control polishing in response to the results of measurements that are taken automatically inside the polishing areas using the reflectivity or film thickness of the films being polished as they are being polished.

[0009]
[Means for Solving the Problems] In order to achieve the goals of solving the problems described above, the manufacturing method and the semiconductor manufacturing device of the present invention are configured as follows below. The semiconductor device and manufacturing method based on the present invention use an optical means for measuring the reflectivity of the film being polished or the film thickness of the film being polished from behind the polishing cloth described above through at least one optical window in the polishing cloth described above at the same time as the polishing is being undertaken. Polishing of the films is then stopped based on the reflectivity or the desired film thickness. Additionally, the semiconductor manufacturing device of the present invention has a measuring module that measures optically, from behind the polishing cloth and through an opening in the polishing cloth, the reflectivity or the film thickness of the film being polished while polishing is underway. It also has a mechanism that controls the polishing based on the results of these measurements.

[0010] As above, the polishing method based on the present invention measures the reflectivity or film thickness of the film being polished inside the area being polished while polishing is under way. For this reason, accurate measurements of the film thickness can be made and, based on those results, the polishing can be controlled, so polishing can always be stopped at exactly the reflectivity or desired film thickness. This will make it possible to improve polished film thickness control considerably.

[0011]
[Embodiments of the Invention] Below refer to drawings as we explain some embodiments of the present invention. Figure 1 (a) is a cross-section of a CMP device based on the present invention. The CMP device has a based disk 10 and polishing cloth 11 that is affixed to the base disk 10, a wafer holder 13 that is attached above the base disk 10 and a slurry supply tube 15 that supplies the slurry 14 to the surface of the polishing cloth 11. The slurry 14 from the slurry supply tube drips onto the surface of the polishing cloth 11. The wafer 12 is pressed against the polishing cloth 11 by the wafer holder 13. The wafer holder 13 and the base disk 10 rotate independently and the wafer 12 is polished by the polishing cloth and the slurry 14.

[0012] In the present invention, an optical sensor window 16 has been formed in part of the polishing cloth 11. Note that this optical sensor window 16 must be sufficiently small enough to have no effect on the polishing characteristics of the CMP.

[0013] Underneath, the optical sensor 17 is affixed to the based disk 10. When the polished film of the wafer 12 is illuminated by the light, the optical sensor receives and measures the reflected light. By analyzing it, the reference or the film thickness of the film being polished can be known.

[0014] The control device 18 changes the polishing ratio based on the values that were actually measured using this optical sensor 17. A number of methods for building controls to change the polishing ratio are listed below. Firstly, in other words, the control device 18 could control the rpm of the wafer holder 13 and the base disk 10. Secondly, the control device 18 could increase or decrease the dilution ratio using purified water to control the concentration of the polishing agent in the slurry 14. Furthermore, a third method would be for the control device 18 to adjust the position of the wafer holder 13 to control the pressure of the wafer 12 against the polishing cloth 11. It would also be possible to control using a combination of all of these methods. Using these methods, the control device 18 controls the polishing ratio based on the reflectivity or the film thickness that are measured.

[0015] Note that in Figure 1(a), the optical sensor 17 is affixed and integrated into the base disk 10 and it turns along with the base disk 10. However, the present invention is not limited to this. An opening could be formed in the base disk 10 and the optical sensor 17 could be installed separately into the base disk 10.

[0016] However, the optical sensor window 16 in the polishing cloth 11 must be sufficiently small, that it has no effect on the polishing characteristics of the CMP. We will explain this using Figure 1 (b). Figure 1(b) is an overhead, schematic diagram of the CMP device of the present invention. Compared with the polishing cloth 11, the optical sensor window 16 is formed sufficiently small. Furthermore, the optical sensor window 16 turns around the center Q along with the polishing cloth 11. Each time it passes under the wafer 12, which is being pressed against the polishing cloth 11 by the wafer holder 13, the optical sensor 17 measures the light that is reflected from the film being polished.

[0017] Below we will explain the polishing method using the CMP device of the present invention offering specific examples. In the first embodiment, the film to be polished could be W, Al, Cu or other metal film with a high degree of reflectivity. Figure 2 shows the formation of embedded wiring using these metal films with the CMP device of the present invention. To explain, Figure 2(a) shows a cross section diagram of the semiconductor device immediately following the build-up of the metal film 30, which is the embedded wiring material that forms contact holes or grooves for wiring in the insulating film 29 between layers. This metal film 30 is polished, removing the metal film except where the embedded wiring will be as shown in Figure 2 (b). We are only considering leaving the embedded wiring in this case.

[0018] First, at the same time that polishing begins (time $t = 0$), the optical sensor 17 starts measuring the reflected light. Each time the base disk 10 makes one revolution, the optical sensor 17 passes under the wafer. During that period, it measures the reflectivity r of the wafer surface.

[0019] Figure 2 (c) shows the changes in the reflectivity of the surface with respect to the polishing time t. At this point, when polishing started, the surface of the accumulated metal film 30 was completely covered, so the reflectivity R_0 is measured for metal film 30. As polishing progresses, as the metal film is removed except for the areas of embedded wiring, the reflectivity of the insulated film 29 between layers, which occupies a significant portion of the wafer, is measured by the optical sensor 17 and a decline in reflectivity is detected. The point ($t = Tc$) at which the control device 18 receives this data is where the polishing will be stopped.

[0020] With this method, the optical sensor always detects declines in the reflectivity of the metal film within the area being polished, so the exact times at which the metal film is removed (except for the embedded wiring areas) can be detected, making it possible to obtain the desired embedded form with a high degree of control.

[0021] Note that in the embodiment above, the control device 18 stopped the polishing process when it detected a decline in reflectivity in areas other than the embedded wiring as the metal film was polished, but in the second embodiment, we will explain a method in which residual metal film is eliminated within the wafer area. In this method, the reflectivity is constantly observed and when the metal film is polished outside of the embedded wiring areas and a decline in the reflectivity is detected, polishing will not be stopped until after the polishing for a suitable amount of additional time T_0. In this way, even when there is variation in the metal film thickness over the wafer surface, there will be no residual metal film, which will prevent short circuits in the wiring.

[0022] As a third embodiment, we have assumed that the film to be polished is an insulating film between layers. We will use Figure 3 to explain the flattening of insulating film between layers by polishing with the CMP device of the present invention. Figure 3(a) shows a cross section of the semiconductor device immediately after the film thickness of the insulating film 40 between layers on the electrode 39 had been built up to the film thickness X_0. This insulating film 40 between layers is polished until the desired film thickness Xc has been reached and the flattening is carried out as shown in Figure 3 (b).

[0023] Figure 3 (c) shows the film thickness x of the insulating film 40 between layers with respect to the polishing time t. First, simultaneously with the starting of polishing (time $t = 0$), the optical sensor 17 begins measuring the reflected light. Each time the base disk 10 makes one revolution, the optical sensor 17 passes underneath the wafer and while it does, it measures the film thickness x of the insulating film 40 between layers. The control device 18 receives this data and, when the desired value Xc for the film thickness of the insulating layer 40 between layers has been reached ($t = Tc$), polishing will be stopped. (See solid line).

[0024] Incidentally, the polishing ratio varies due to other effects such as the state of the surface of the polishing cloth. The dotted line (f) in Figure 3 (c) shows a large polishing ratio while the dotted line (s) in Figure 3 (c) shows a small polishing ratio. In response to variations in the polishing ratio such as these, the times at which the desired film thicknesses are reached vary as shown with Tf and Trading Status. Using the method of this embodiment, the residual film thickness is always being monitored inside the area being polished, so the polishing can be stopped when the film thickness of the insulating film 40 between layers reaches the desired value Xc ($t = Tf$, or Ts). In other words, the desired film thickness Xc can always be achieved by increasing or decreasing the polishing time in response to variations in the polishing ratio.

[0025] In the fourth embodiment, we explain a polishing method that improves the polishing throughput and improves the control of the film thickness of the films being polished as well. Just as in the third embodiment described above, we will use an insulating film between layers as the film to be polished. Moreover, we will explain a case in which this insulating film between layers is flattened and polished using the CMP device of the present invention.

[0026] Figure 4 shows the film thickness x of the insulating film 40 between layers with respect to the polishing time t. The solid line (a) corresponds to the shape in this embodiment while the solid line (b) corresponds to the shape in the third embodiment described above. Below, our explanation will apply to the solid line (a).

[0027] First, simultaneously when polishing starts (time $t = 0$), the optical sensor 17 starts measuring the reflected light. Each time the base disk 10 makes one revolution, the optical sensor 17 passes under the wafer and measures the film thickness x of the insulating film 40 between layers.

[0028] Note that with the goal of improving throughput, we have increased the concentration of the polishing agent in the slurry right when polishing begins, setting the polishing ratio slightly higher. Then, the point T_1 at which the film thickness of the insulating film 40 between layers reaches X_1, which is close to the desired film thickness X_2, the control device 18 will lower the concentration of the polishing agent in the slurry 14 and lower the polishing ratio. Then, when (at T_2) the film thickness of the insulating film 40 between layers reaches the desired film thickness X_2, the control device 18 will stop polishing.

[0029] With this embodiment, the polishing ratio right before polishing ends is so small that the variation in film thickness can be reduced with respect to the variation in polishing time. For example, as shown in Figure 4, with respect to the variation in polishing time ΔT, the film thickness variation ΔX_2 can be made smaller than the variation ΔX_3 described in the first embodiment above. Moreover, since the polishing ratio was set higher right at the beginning ($t = 0 \sim T_1$) of polishing, the overall time T_2 required for polishing can be made shorter than the polishing time T_3 in the first embodiment described above. In this way, this embodiment allows improvements in throughput and improvements in control over the film thickness of the films being polished.

[0030] Not that in the Embodiment 4 above, by changing the concentration of the polishing agent in the slurry 14, we changed the polishing ratio, but the present invention is not limited to this method. It would also be possible to vary the rpm of the base disk 10 or the wafer holder 13 or both in order to vary the polishing rate. Or, by adjusting the position of the wafer holder 13, it would be possible to vary the polishing ratio by varying the amount of pressure placed on the wafer 12.

[0031]

[Effect of the Invention]

By using the polishing method of the present invention, it is possible to constantly measure film thickness that is equivalent to the actual film being polished without having differences in polishing times between areas being polished and areas where film thickness is being measured as was the case in conventional polishing methods using CMP devices. This is because the reflectivity or the film thickness of the film being polished is constantly being measured from behind the polishing cloth through the optical window in the polishing cloth while polishing is underway. Thus, by using the polishing method of the present invention, which controls the polishing in response to the results of measurements, it is possible to obtain the desired results even more precisely than was possible using conventional polishing methods. Additionally, the CMP device of the present invention uses only one optical sensor, so it has better economic efficiency than conventional methods which require two optical sensors. Moreover, a measuring means is only needed on one side of the wafer, so the device configuration can also

[Brief Explanation of Drawings]

[Figure 1] is a diagram showing the structure of the CMP device of the present invention.
[Figure 2] is a diagram that explains the first embodiment based on the CMP of the present invention.
[Figure 3] is a diagram that explains the third embodiment based on the CMP of the present invention.
[Figure 4] is a diagram that explains the fourth embodiment based on the CMP of the present invention.
[Figure 5] is a diagram showing a traditional CMP device.

[Description of the Numbers and Symbols]

O, Q: rotating spindles; 10: base disk; 11: polishing cloth; 12: wafer; 13: wafer holder; 14: slurry; 15: slurry supply tube; 16: optical sensor window; 17: optical sensor; 18: control device; 39: electrode; 29, 40: insulating film between layers; 30: metal film; 110: upper lathe; 111: lower lathe; 112: carried; 113: wafer; 114: measuring module; 115, 116: laser light sensor.

Figure 1	Figure 2
[see source for diagram]	[see source for diagram]
(b)	(c) reflectivity r Polishing Time t

Figure 3	Figure 4
[See source for diagrams]	Film Thickness X Polishing Time t
Film Thickness X Polishing Time t	
Figure 5	

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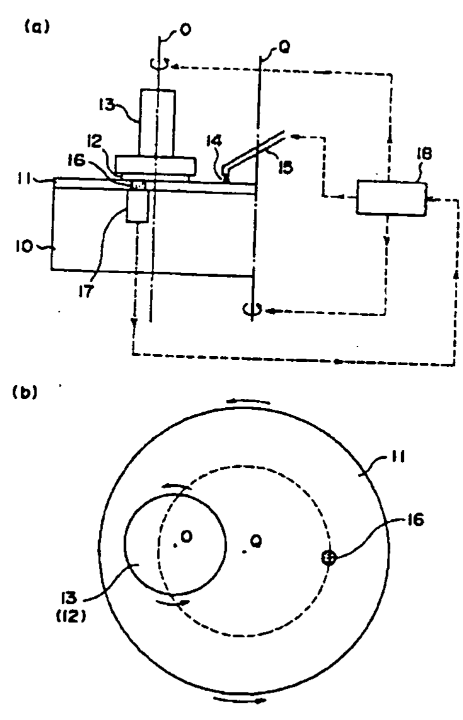
(54)【発明の名称】　半導体装置の製造方法および製造装置

(57)【要約】

【課題】研磨中の被研磨膜の膜厚あるいは反射率を測定し、所望の膜厚あるいは反射率で研磨を終了させることができる半導体装置の製造方法を提供し、研磨中の被研磨膜の膜厚あるいは反射率を自動で測定し、その測定結果に応じて研磨を制御する機構を有する半導体製造装置を提供する。

【解決手段】被研磨膜を有するウェハを、研磨クロスを用いて研磨する半導体装置の製造方法において、研磨と同時に、研磨クロス内に設けられた光学的窓を通して、前記研磨クロスの裏面側から、被研磨膜の膜厚あるいは被研磨膜面の反射率を、光学的手段を用いて測定する。



【特許請求の範囲】

【請求項１】　被研磨膜を有するウェハを、研磨クロスを用いて研磨する半導体装置の製造方法において、前記研磨クロス内に少なくとも一つの光学的窓を開口し、研磨中にこの窓を通して、前記研磨クロスの裏面側から、被研磨膜の膜厚あるいは被研磨膜面の反射率を、光学的手段を用いて測定することを特徴とする半導体装置の製造方法。

【請求項２】　前記光学的手段によって測定した被研磨膜の膜厚あるいは被研磨膜面の反射率が、所定の値に達した時点で研磨を終了させることを特徴とする請求項１記載の半導体装置の製造方法。

【請求項３】　前記光学的手段によって測定した被研磨膜の膜厚あるいは被研磨膜面の反射率に応じて研磨率を変化させることを特徴とする請求項１記載の半導体装置の製造方法。

【請求項４】　被研磨膜を有するウェハを、研磨クロスを用いて研磨する半導体製造装置において、研磨クロスに少なくともひとつの開口部を備え、この開口の背後に、研磨中に研磨クロスの裏面側から、光学的手段を用いてウェハ表面の被研磨膜の膜厚あるいは被研磨膜面の反射率を測定する測定装置を具備することを特徴とする半導体製造装置。

【請求項５】　研磨クロスの開口部が、測定に用いる光に対して透過率の大きな材料で構成されていることを特徴とする請求項４記載の半導体製造装置。

【請求項６】　研磨中に被研磨膜の膜厚あるいは被研磨膜面の反射率に応じて、スラリー中の研磨剤濃度を変化させる制御装置を具備することを特徴とする請求項４記載の半導体製造装置。

【請求項７】　研磨中に被研磨膜の膜厚あるいは被研磨膜面の反射率に応じて、研磨クロスの張られた底盤の回転速度およびウェハの回転速度を変化させる制御装置を具備することを特徴とする請求項４記載の半導体製造装置。

【請求項８】　研磨中に被研磨膜の膜厚あるいは被研磨膜面の反射率に応じて、研磨クロスに対してウェハに加えられる圧力を変化させる制御装置を具備することを特徴とする請求項４記載の半導体製造装置。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、半導体装置の表面を平坦化する方法およびその装置に関し、特に、半導体装置の表面をＣＭＰ（Ｃｈｅｍｉｃａｌ　Ｍｅｃｈａｎｉｃａｌ　Ｐｏｌｉｓｈｉｎｇ　：化学的機械研磨）法により平坦化する場合に関する。

【０００２】

【従来の技術】半導体装置の微細化、高集積化に伴い、半導体装置の表面の段差が問題となってきている。そのため表面を平坦化する方法として、ＣＭＰ法が注目されている。以下、従来のＣＭＰ法を簡単に説明する。まずＣＭＰ装置の研磨クロスを張り替えて研磨を開始する時、研磨率を測定するために、サンプル用のウェハを研磨する。なおサンプル用のウェハの初期膜厚はあらかじめ測定しておく。研磨後の残膜厚と初期膜厚および研磨時間とから、研磨率を算出する。この後のウェハの研磨においては、この研磨率に基ずいて、所望の膜厚にするために算出した時間で研磨を行う。

【０００３】しかし、ＣＭＰ法における研磨率は、研磨クロスの表面状態に依存して変動する。そのため、多数枚のウェハを固定された研磨時間だけ研磨すると、研磨率の変動に伴い残膜厚にばらつきが生じるという問題があった。この様なばらつきを最小限に押さえるため、従来のＣＭＰ法では、ウェハを数枚研磨する毎に研磨時間の設定を見直す作業を必要としていた。この見直し作業は多大な時間と手間がかかり、装置のスループットを落とす原因となっていた。

【０００４】この様な問題を解決する方法として、研磨を行うと同時に膜厚の測定を行う方法が提案されている（特開平５－３０９５５９号公報）。この方法を図５を用いて簡単に説明する。図５（ａ）は従来例による研磨装置の断面図、図５（ｂ）は上定盤を除いた平面図である。遊星運動するキャリア１１２上に保持されたウェハ１１３が、上定盤１１０および下底盤１１１により加圧研磨される。このウェハ１１３は、研磨加工中に上下の定盤１１０、１１１から部分的にオーバーハングし、測定点１１４において、上下に設置されたレーザー変位センサ１１５、１１６を用いてウェハ上下面の位置が検出され、演算処理により膜厚が測定される。

【０００５】しかし、この方法では、膜厚測定のためにオーバーハングされたウェハの外周部分はオーバーハングされない他の内周部分に比べて、常に短い時間しか研磨されず、したがって測定部分とその他の部分において、実際には膜厚が異なるという問題がある。さらにこの研磨装置ではウェハ上下面の位置を測定し演算処理により膜厚を測定しているが、例えば干渉を利用して、直接被研磨膜の膜厚を測定する方法に比べて、測定精度が劣る。また、ウェハ上下方向から位置を測定するためにレーザー変位センサを二つ必要とするため、経済効率が悪い。

【０００６】

【発明が解決しようとする課題】このように、従来のＣＭＰ装置による研磨方法では、被研磨部分と膜厚測定部分との間に研磨時間の差を生じてしまい、正確な膜厚が測定できず、所望の膜厚で研磨を終了させることは困難であった。

【０００７】本発明の第１の目的は、研磨中の被研磨膜の膜厚あるいは反射率を研磨領域内で直接測定し、所望の膜厚あるいは反射率で研磨を終了させることができる半導体装置の製造方法を提供することである。

【０００８】本発明の第２の目的は、研磨中の被研磨膜の膜厚あるいは反射率を研磨領域内で自動測定し、その測定結果に応じて研磨を制御する機構を有する半導体製造装置を提供することである。

【０００９】

【課題を解決するための手段】上記課題を解決し目的を達成するために、本発明の半導体装置の製造方法はおよび半導体製造装置は、以下の如く構成されている。本発明による半導体装置の製造方法は、研磨と同時に、前記研磨クロス内に開口された少なくとも一つの光学的窓を通して、前記研磨クロスの裏面側から、被研磨膜の膜厚あるいは被研磨膜面の反射率を、光学的手段を用いて測定することにより、所望の膜厚あるいは反射率で、被研磨膜の研磨を終了させることを特徴とする。また本発明による半導体製造装置は、研磨クロス内部に設けられた開口部を通して研磨クロス裏面側から光学的に被研磨膜の膜厚あるいは反射率を研磨中に測定する測定部と、測定結果に応じて、研磨を制御する機構を有することを特徴とする。

【００１０】このように、本発明による研磨方法では被研磨膜の膜厚あるいは反射率を研磨中に被研磨領域内で測定するため、膜厚を正確に測定することができ、その結果に応じて研磨を制御するので、常に所望の膜厚あるいは反射率で正確に研磨を終了させることができ、研磨膜厚の制御性の大幅な向上を図ることができる。

【００１１】

【発明の実施の形態】以下、本発明の実施の形態について図面を参照して説明する。図１（ａ）は本発明によるＣＭＰ装置の断面図である。ＣＭＰ装置は底盤１０と底盤１０上にはられた研磨クロス１１と、底盤１０の上方に設けられたウェハホルダ１３と、スラリー１４を研磨クロス１１上に供給するスラリー供給管１５とを有する。スラリー供給管１５からスラリー１４が研磨クロス１１上に滴下される。ウェハ１２はウェハホルダ１３により研磨クロス１１に対して加圧される。ウェハホルダ１３および底盤１０がそれぞれ回転し、ウェハ１２は研磨クロスおよびスラリー１４で研磨される。

【００１２】本発明においては、研磨クロス１１の一部には光学用センサ窓１６が形成されている。なお、この光学用センサ窓１６はＣＭＰの研磨特性には影響を与えない程度に十分小さくなければならない。

【００１３】この下には、光学センサ１７が底盤１０に固定されている。光学センサはウェハ１２の被研磨膜に光を照射し、その反射光を受光測定し、解析することにより、被研磨膜の膜厚または反射率を検知する。

【００１４】この光学センサ１７で得られた実測値に応じて、制御装置１８は研磨率を変化させる。研磨率を変化させるための制御には例えば次のようないくつかの方法がある。すなわち、第１に制御装置１８は底盤１０およびウェハホルダ１３の回転数を制御することができる。また、第２に制御装置１８は、例えば純水を用いて希釈率を増減することにより、スラリー１４中の研磨剤濃度を制御することができる。さらに、第３に制御装置１８はウェハホルダ１３の位置を調節することにより、ウェハ１２の研磨クロス１１に対する圧力を制御することができる。またこれらの方法を組み合わせて制御することも可能である。それらの方法により、制御装置１８は測定された膜厚または反射率に基づいて、研磨率を調節する。

【００１５】なお、図１（ａ）では光学センサ１７は底盤１０に一体化して固定されており、底盤１０と共に回転するようになっているが、これに限らず、底盤１０にも開口部を形成し、光学センサ１７は底盤１０と別に設置してもよい。

【００１６】ところで、光学用センサ窓１６はＣＭＰの研磨特性には影響を与えない程度に十分小さく研磨クロス１１内部に形成されなければならない。この様子を図１（ｂ）を用いて説明する。図１（ｂ）は本発明によるＣＭＰ装置を上から見た概略図である。光学用センサ窓１６は研磨クロス１１に比べて、十分に小さく形成されている。さらに、光学用センサ窓１６が研磨クロス１１と共にＱを中心として回転し、ウェハホルダー１３により研磨クロス１１に加圧されているウェハ１２の下を通過する度に、光学センサ１７は被研磨膜からの反射光を観測する。

【００１７】以下、本発明によるＣＭＰ装置を用いた研磨方法について具体的に例を挙げながら説明する。第１の実施の形態として、被研磨膜として例えばＷ、Ａｌ、Ｃｕのような反射率の高い金属膜を使用して、これら金属膜の埋め込み配線を本発明によるＣＭＰ装置を用いて形成する場合を、図２を用いて説明すると、図２（ａ）は層間絶縁膜２９に配線用の溝もしくはコンタクトホールを形成した後埋め込み配線材料として金属膜３０が堆積された直後の半導体装置の断面図である。この金属膜３０を研磨して、図２（ｂ）に示すように埋め込み配線部以外の金属膜を除去し、埋め込み配線部のみに残す場合を考える。

【００１８】まず研磨が開始すると同時（時刻ｔ＝０）に光学センサ１７は反射光の測定を開始する。光学センサ１７は底盤１０が一回転する度に一回、ウェハの下を通過し、この間にウェハ表面の反射率ｒを測定する。

【００１９】図２（ｃ）は研磨時間ｔに対する表面の反射率の変化を示している。研磨開始当初は堆積された金属膜３０が表面全体を覆っているためこの金属膜３０の反射率R_0が測定される。研磨が進み、埋め込み配線部以外の金属膜が除去されると、光学センサ１７はウェハの大部分を占める層間絶縁膜２９の反射率R_1を測定し、反射率の低下が検知される。制御装置１８はこの情報を受けた時点（ｔ＝Ｔｃ）で研磨を終了させる。

【００２０】この方法によれば、光学センサ１７が金属

膜の反射率の低下を常に被研磨領域内で検知するため、埋め込み配線部以外の金属膜が除去される時刻を正確に検知することができ、制御性良く所望の埋め込み形状を得ることができる。

【0021】なお、前記実施の形態では、制御装置18は、埋め込み配線部以外の金属膜が研磨されて反射率の低下が検出された時点で研磨を終了させていたが、第2の実施の形態として、ウェハ面内における金属膜の残りをなくす方法を説明する。この方法では、反射率を常に観測し、埋め込み配線部以外の金属膜が研磨されて反射率の低下が検出された時点よりさらに適切な時間T_0だけ長い時間研磨を行ったのちに研磨を終了させる。このようにすれば、ウェハ面内で金属膜厚にばらつきがある場合でも、金属膜が残ることが無く、配線のショートを防ぐことができる。

【0022】第3の実施の形態として、被研磨膜として層間絶縁膜を想定し、この層間絶縁膜を本発明によるCMP装置を用いた研磨により平坦化する場合を、図3を用いて説明する。図3（a）は電極39上に層間絶縁膜40が膜厚X_0で堆積された直後の半導体装置の断面図である。この層間絶縁膜40を所望の膜厚Xc まで研磨して、図3（b）に示すように平坦化する場合を考える。

【0023】図3（c）は研磨時間tに対する層間絶縁膜40の膜厚xを示している。まず研磨が開始すると同時（時刻t＝0）に光学センサ17は反射光の測定を開始する。光学センサ17は底盤10が一回転する度に一回、ウェハの下を通過し、この間に層間絶縁膜40の膜厚xを測定する。制御装置18はこの情報を受けて、層間絶縁膜40の膜厚が所望の値Xc に達した時点（t＝Tc）で研磨を終了させる（実線参照）。

【0024】ところで、研磨クロスの表面状態その他の影響により、研磨率は変化することがある。図3（c）中の破線（f）は研磨率が大きい場合、図3（c）中の破線（s）は研磨率が小さい場合をそれぞれ示している。この様に研磨率の変動に対応して、所望の膜厚に達する時刻はそれぞれTf，Tsのように変化する。本実施の形態の方法によれば残膜厚を被研磨領域内で常に観測しているため、層間絶縁膜40の膜厚が所望の値Xc に達した時点（t＝Tf、もしくはTs）で研磨を終了させることができる。すなわち、研磨率の変動に対応して、研磨時間を増減させることにより、常に所望の膜厚Xc を得ることができる。

【0025】第4の実施の形態として、研磨のスループットを改善し、さらに被研磨膜の膜厚の制御性を向上させる研磨方法について説明する。前記第3の実施の形態と同様に、被研磨膜として層間絶縁膜を使用し、この層間絶縁膜を本発明によるCMP装置を用いた研磨により平坦化する場合を説明する。

【0026】図4は研磨時間tに対する層間絶縁膜40の膜厚xを示している。実線（a）は本実施の形態に対応し、実線（b）は前記第3の実施の形態に対応している。以下、実線（a）にしたがって説明する。

【0027】まず研磨が開始すると同時（時刻t＝0）に光学センサ17は反射光の測定を開始する。光学センサ17は底盤10が一回転する度に一回、ウェハの下を通過し、この間に層間絶縁膜40の膜厚xを測定する。

【0028】なお、研磨開始当初はスループットの向上を目的として、スラリー中の研磨剤濃度を高くして、研磨率を大きめに設定しておく。そして層間絶縁膜40の膜厚が所望の膜厚X_2 に近い値X_1 になった時点T_1 で制御装置18はスラリー14中の研磨剤濃度を低下させ、研磨率を低下させる。そして層間絶縁膜40の膜厚が所望の値X_2 になった時点T_2 で制御装置18は研磨を終了させる。

【0029】本実施の形態によれば研磨終了間際の研磨率が小さいために研磨時間のばらつきに対する膜厚のばらつきを小さく抑えることができる。例えば、図4に示すように、研磨時間のばらつきΔTに対する膜厚のばらつきΔX_2 は前記第1の実施の形態による膜厚のばらつきΔX_3 よりも小さくすることができる。さらに研磨開始当初（$t=0\sim T_1$）の研磨率を高く設定しているため、研磨にかかる全体の時間T_2 は、前記第1の実施の形態における研磨時間T_3 よりも短くてすむ。この様に本実施の形態によれば研磨のスループットを改善し、さらに被研磨膜の膜厚の制御性を向上させることができる。

【0030】なお前記第4の実施の形態では、スラリー14中の研磨剤濃度を変えることで、研磨率を変化させたが、これに限らず、底盤10とウェハホルダ13の少なくとも一方の回転数を変化させることにより研磨率を変化させることも可能である。あるいは、ウェハホルダ13の位置を調節することによりウェハ12に加えられる圧力を変化させることで研磨率を変化させることもできる。

【0031】

【発明の効果】本発明による研磨方法によれば、研磨クロス内に開口された光学的窓を通して研磨中にこの研磨クロス裏面側から被研磨膜の膜厚あるいは反射率を測定しているので、従来のCMP装置による研磨方法のように、被研磨部分と膜厚測定部分との間に研磨時間の差が生じることがなく、実際の被研磨膜と等しい膜厚を常に測定することが可能である。したがって、この測定結果に応じて研磨を制御する本発明による研磨方法によれば、従来の研磨方法よりいっそう正確に所望の結果を得ることができる。また、本発明のCMP装置は光学センサを一つしか必要としないため、光学センサを二つ必要としていた従来の方法に比べ、経済効率が優れており、また測定手段をウェハの一方の側に設置すればよいので、装置の構成も簡略化することができる。さらに、本

発明のＣＭＰ装置は、例えば干渉による光学的手段を用いて直接被研磨膜の膜厚を測定しているため、精度良く膜厚を測定することができるので、より厳密に研磨の制御を行うことができる。

【図面の簡単な説明】

【図１】本発明ＣＭＰ装置の構造を示す図である。

【図２】本発明ＣＭＰ装置による第１の実施の形態の説明図である。

【図３】本発明ＣＭＰ装置による第３の実施の形態の説明図である。

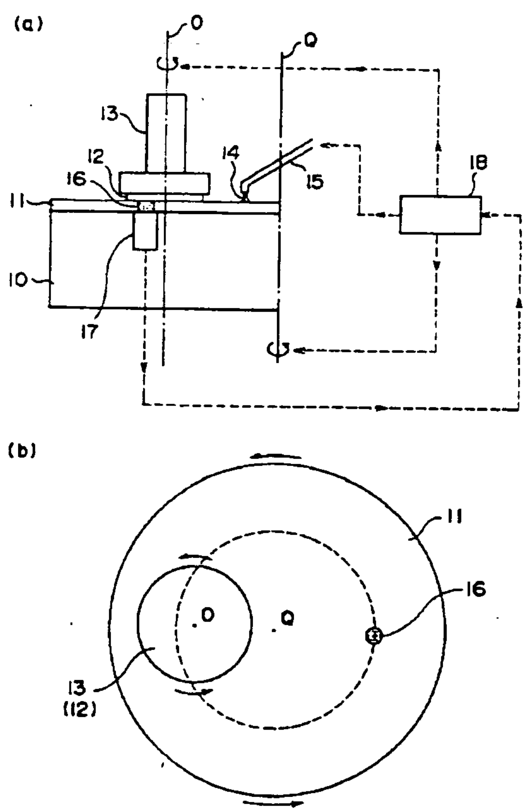
【図４】本発明ＣＭＰ装置による第４の実施の形態の説明図である。

【図５】従来のＣＭＰ装置を示す図である。

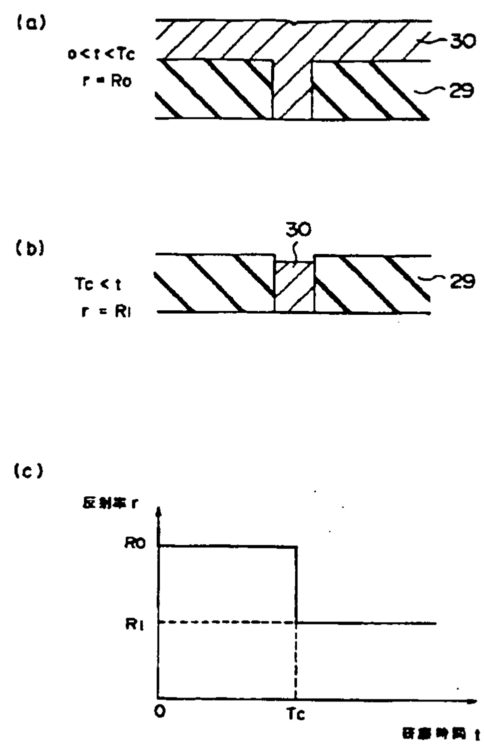
【符号の説明】

Ｏ、Ｑ…回転軸、１０…底盤、１１…研磨クロス、１２…ウェハ、１３…ウェハホルダ、１４…スラリー、１５…スラリー供給管、１６…光学センサ窓、１７…光学センサ、１８…制御装置、３９…電極、２９、４０…層間絶縁膜、３０…金属膜、１１０…上定盤、１１１…下定盤、１１２…キャリア、１１３…ウェハ、１１４…測定部、１１５、１１６…レーザー光学センサ。

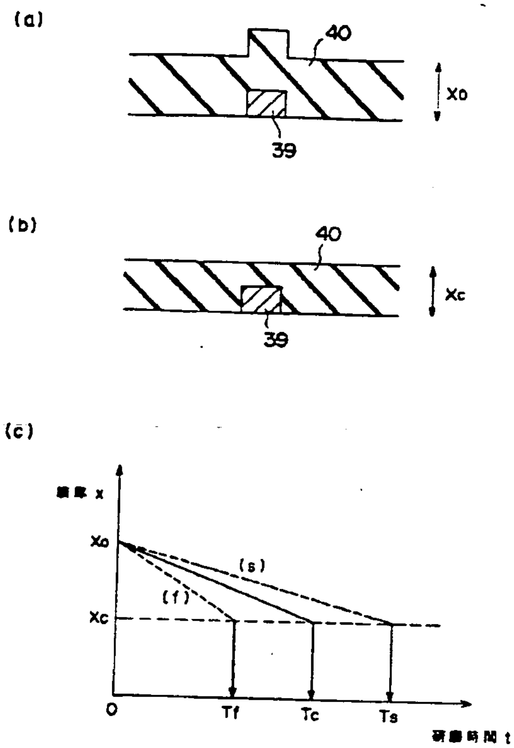
【図１】



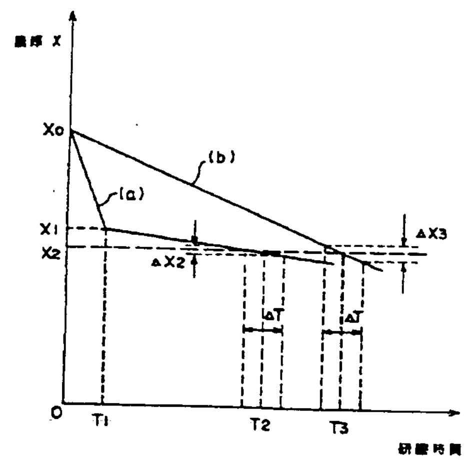
【図２】



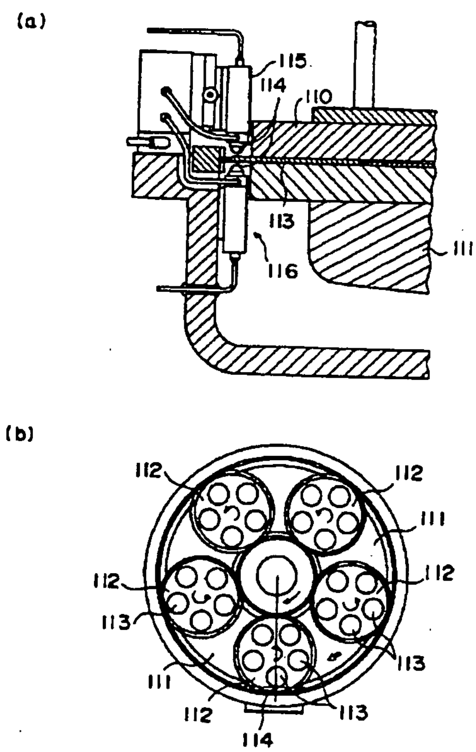
【図3】


(a)
40
Xo
39
(b)
40
Xc
39
(c)
膜厚 x
Xo
(s)
(f)
Xc
0
Tf
Tc
Ts
研磨時間 t

【図4】


膜厚 X
Xo
(b)
(a)
X1
X2
ΔX2
ΔX3
ΔT
ΔT
0
T1
T2
T3
研磨時間 t

【図5】


(a)
115
114
110
113
116
111
(b)
112
112
111
112
112
113
111
113
112
114
113

METHOD AND DEVICE FOR MANUFACTURING SEMICONDUCTOR DEVICE

Patent number: JP9036072
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Inventor: OKAJIMA MUTSUMI
Applicant: TOSHIBA CORP
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- international: H01L21/304
- european:
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Priority number(s):

Abstract of **JP9036072**

PROBLEM TO BE SOLVED: To complete polishing with a desired film thickness or reflection factor by opening an optical window in a polishing cloth and measuring the film thickness of a film to be polished or the reflection factor of the surface to be polished from the reverse side of the polishing cloth through the window during polishing. SOLUTION: An optical sensor window 16 is formed at one portion of a polishing cloth 11 and an optical sensor 17 is fixed to a bottom panel 10 below it. The optical sensor 17 applies light to a film to be polished of a wafer 12, receives and measures the reflection light, and analyzes it to detect the film thickness or the reflection factor of the film to be polished. A control device 18 changes a polishing rate according to an actually measured value obtained by the optical sensor 17. A control device 18 controls the speed of the bottom plate 10 and a wafer holder 13. Also, the control device 18 controls the concentration of a polishing agent in a slurry 14 by increasing or decreasing a dilution rate using, for example, pure water.